Tracking and Analysis Framework

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Resources for the Future

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The development of the Tracking and Analysis Framework (TAF) is a direct result of NAPAP and the Clean Air Act Amendments of 1990
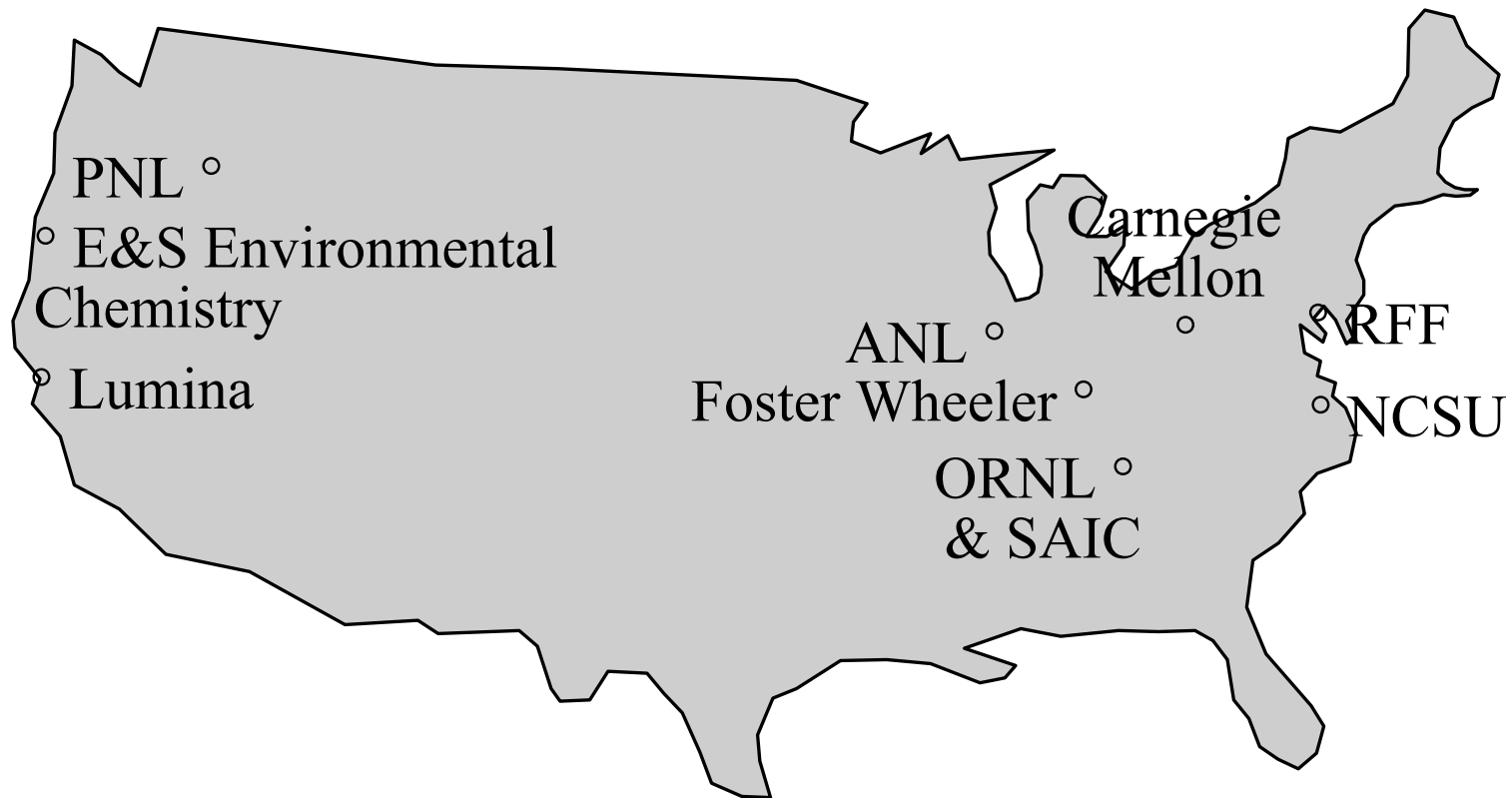
- *NAPAP was asked to conduct a cost/benefit analysis of Title IV of the Clean Air Act*
- *Was Title IV 'worth it' from a policy perspective? Did we go 'far enough'?*

Tools and Processes for Development: TAF Had Unique Needs

- A functionally integrated assessment to yield a single model

- Scientists working across the country required the closest cooperation

- Final model would be useable on a personal computer, freely distributable and extensible, and in the public domain

A Nationwide, Collaborative Effort of 30+ Scientists and Economists...

PNL °
° E&S Environmental
Chemistry
° Lumina

ANL °
Foster Wheeler °

ORNL °
& SAIC

Carnegie
Mellon

° RFF

° NCSU

...Working from 1995 through 1996

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A True Integrated Assessment

- Selection of the **Analytica**® modeling environment for all components

- Incorporation and comparison of uncertainty and variability in each module

- Sensitivity and uncertainty analyses across the entire assessment; not just piecemeal

  An integrated model enables rapid insight followed by successive refinement

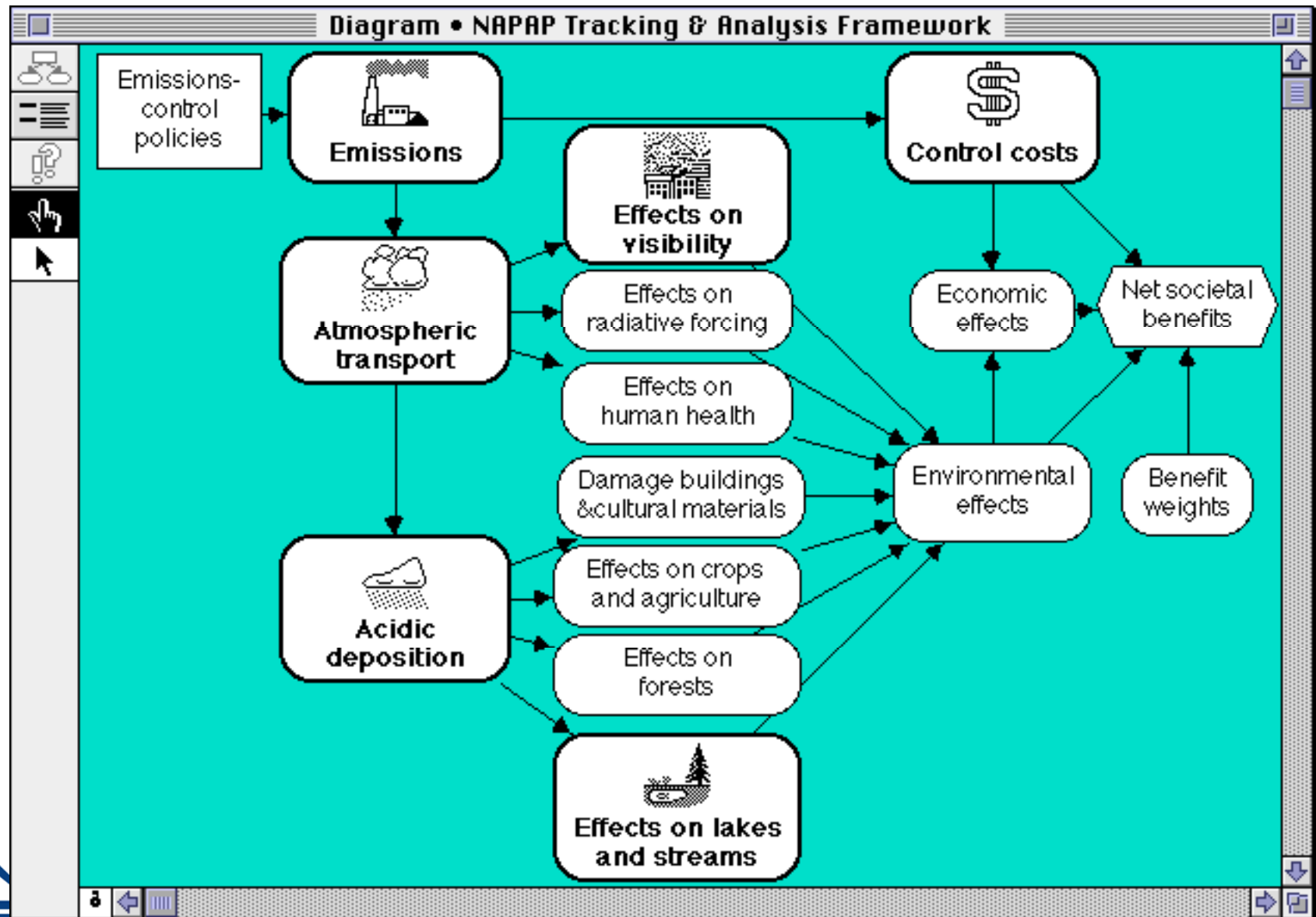# Simultaneously Produced by a Distributed Team

- Adopted software engineering methods for development
  - Specifications for each component; focussing on interfaces between components
  - Library of common variables for time, space, species, etc.
- Progressive refinement of 'critical' modules and variables based on initial analyses of the integrated model
- 3 face-to-face workshops, weekly teleconferences, email list-servers, and a web-based repository for model components helped to ensure project success

  There is no substitute for up-front planning and face to face meetings to hammer out interface details

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TAF Going Forward

- Public Domain: www.lumina.com\taflist

- Analytica platform (PC and Mac)

- Ongoing development at RFF, U.Maine

- Technical support by ENRICH and Lumina

- Web interface

- Monte Carlo uncertainty analysis

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TAF- Version 1.0 (ca.1994)

Diagram • NAPAP Tracking & Analysis Framework

Emissions-control policies → Emissions → Control costs

Emissions → Atmospheric transport

Atmospheric transport → Effects on visibility

Atmospheric transport → Effects on radiative forcing

Atmospheric transport → Effects on human health

Atmospheric transport → Acidic deposition

Acidic deposition → Damage buildings & cultural materials

Acidic deposition → Effects on crops and agriculture

Acidic deposition → Effects on forests

Acidic deposition → Effects on lakes and streams

Control costs → Economic effects → Net societal benefits

Environmental effects → Net societal benefits

Benefit weights → Net societal benefits

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NAPAP boundaries were largely a function of science

- Extensive resources were spent on characterizing the airborne transport of emissions...

  …but other processes proved to be critical drivers of costs and benefits

  - Coal transport cost trends with rail deregulation
 - Epidemiology of human exposure to PM10

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Using Progressive Refinement to Reallocate Limited Resources

- Ability to model pollutant pathways and effects was uneven given state of sciences

- Preliminary analysis of endpoints (benefits and costs) indicated need to expand analysis of health and visibility

- Value of Information (VOI) approach led to reallocation of effort away from terrestrial effects toward health and visibility
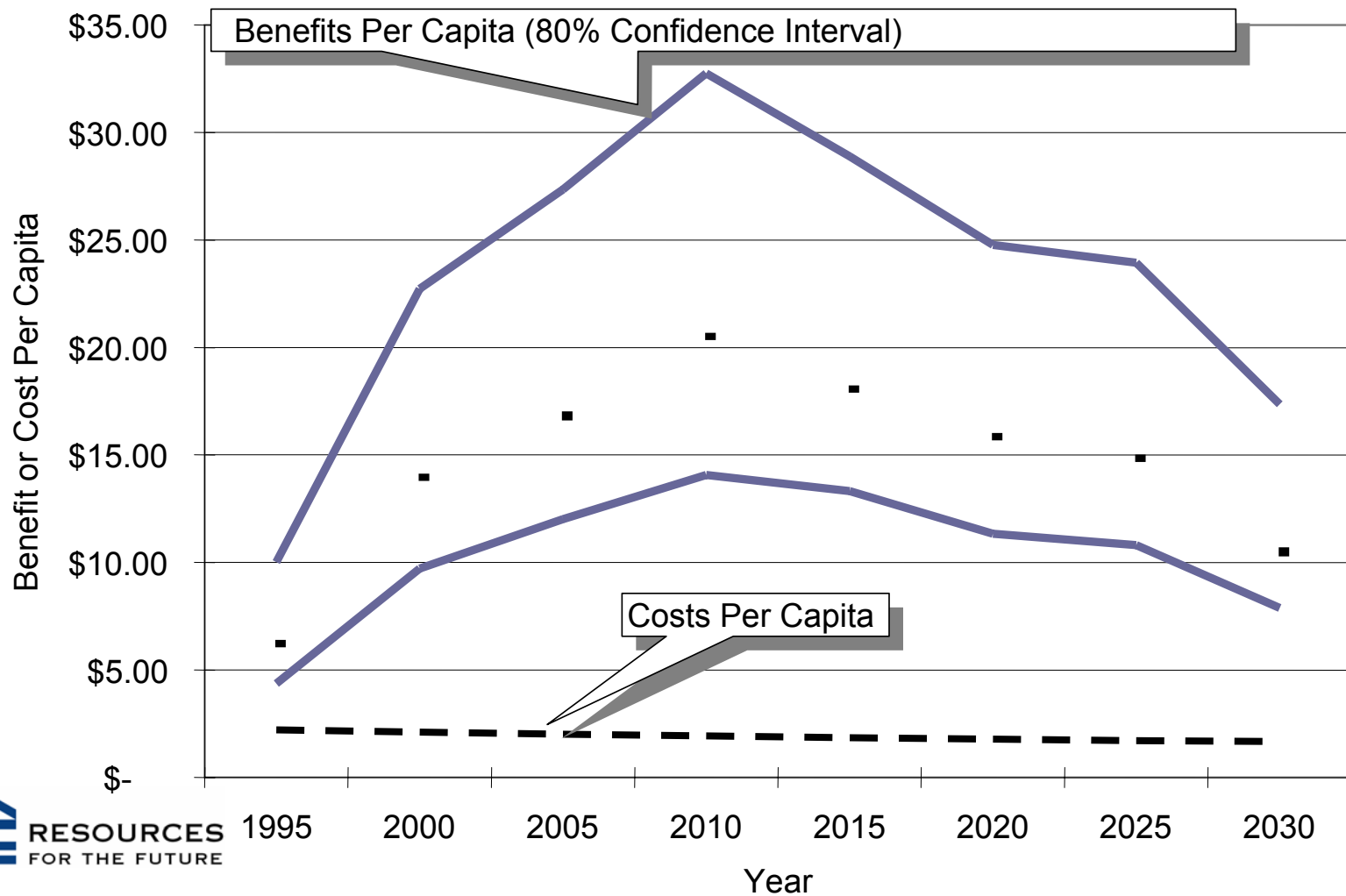
TAF- Version 2.0 (ca.1996)
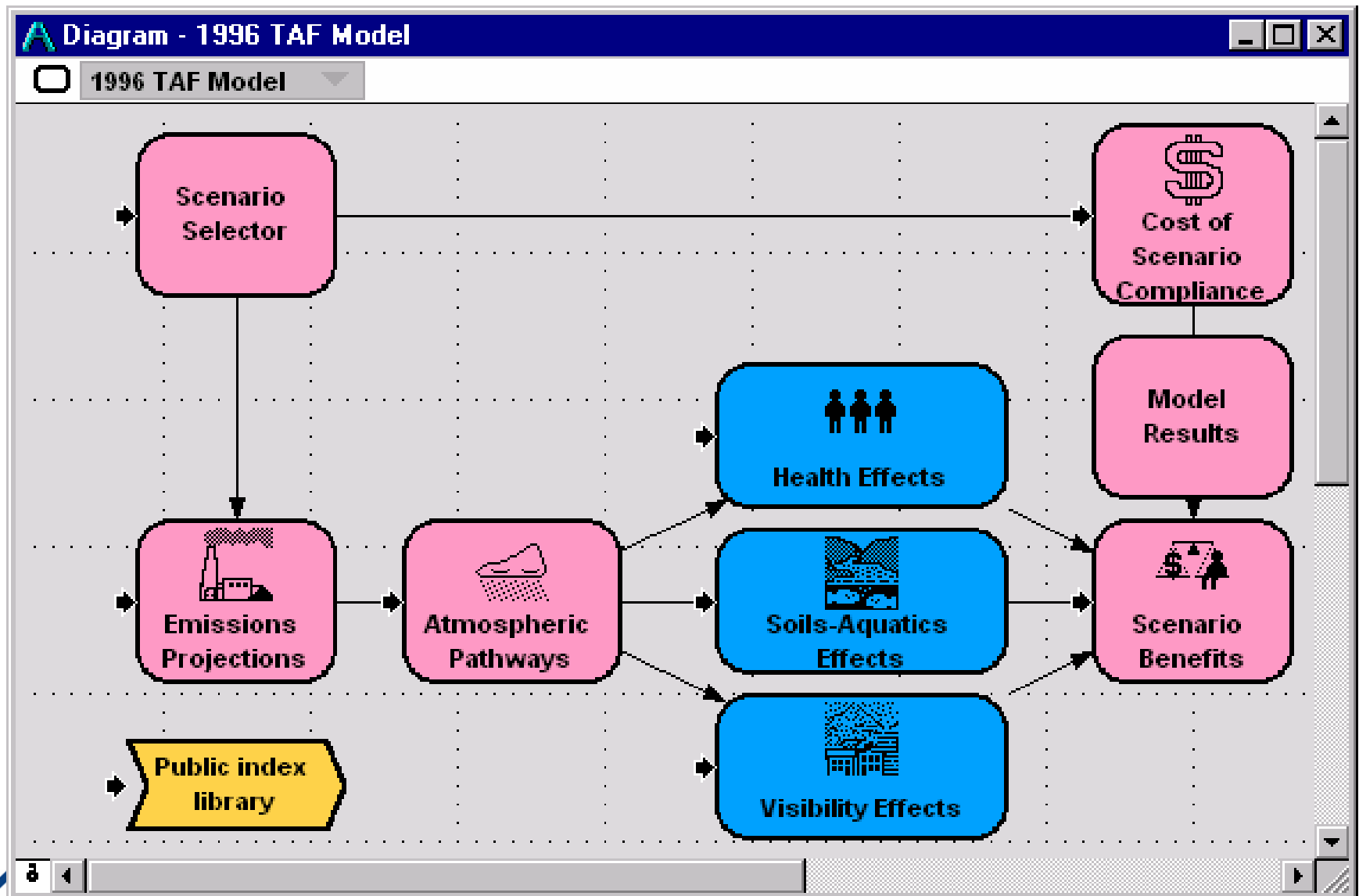
Benefits for Assessed Effects
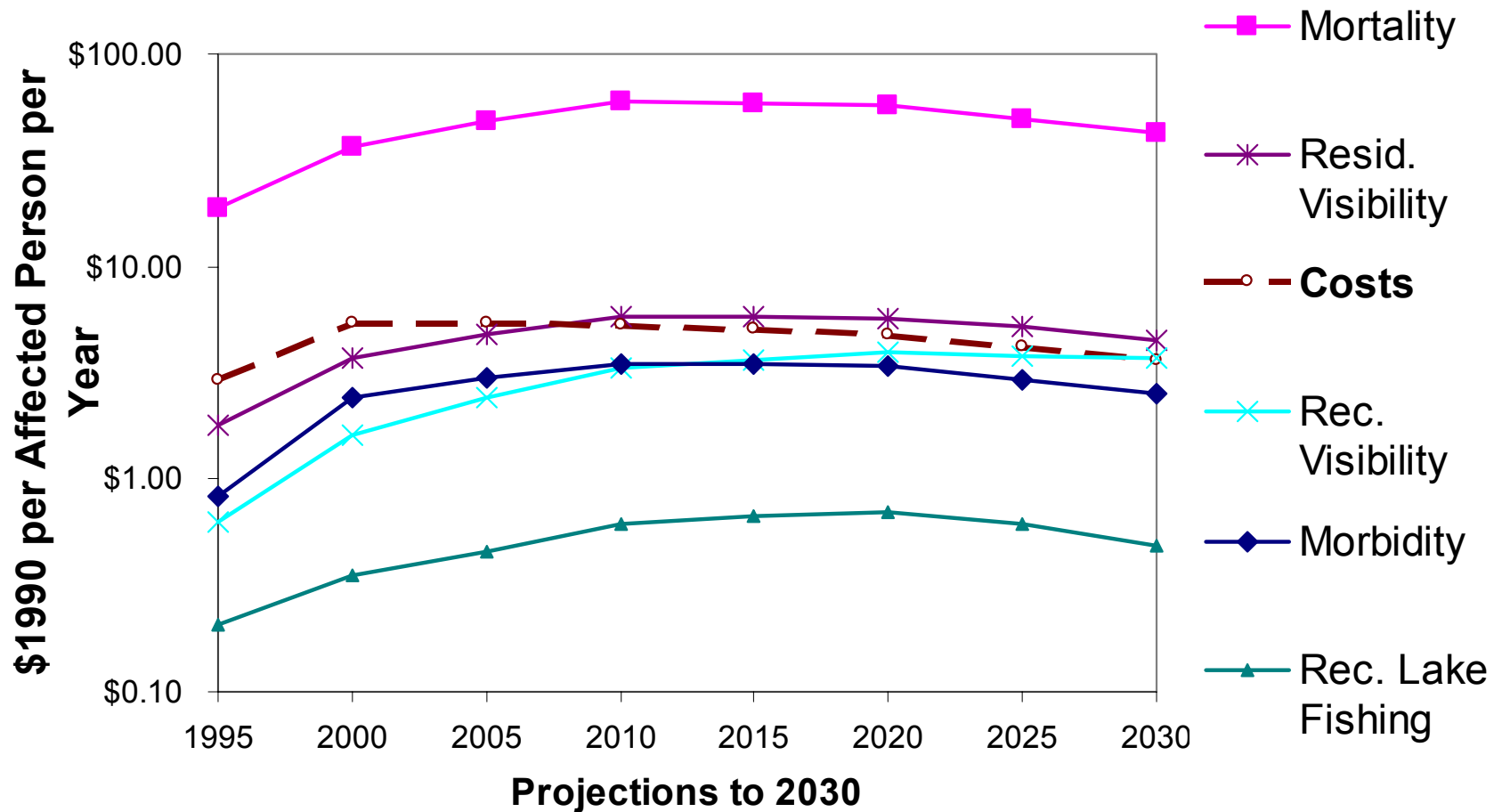
Uncertainty in Benefits, But Assessed Benefits Still Exceed Assessed Costs

Value of Additional Information for Subsequent Policy and Assessment

- Integrated assessment guides identification of priorities for future research.

- Inter-disciplinary team mapped out many environmental pathways leading to important endpoints (effects); not all could be assessed.

- Weak links in the assessment chain were identified by internal and peer review, and remedied or removed.

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The Weak Links

	Expected Benefit:	Short-Term Value of Additional Information:
Health: Mortality	●	●
Health: Morbidity	◉	◉
Visibility	◉	◉
Materials and Cultural Resources	◉	◉
Nonuse Values: Ecosystem Health	●	⬤
Aquatics: Recreation	⊙	⬤
Forests: Recreation	⊙	⬤
Ag / Commercial Forestry	⬤	⊙
Radiative Forcing	⊙	○

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Categories
- ● high
- ◉ high-mid
- ◐ mid
- ⊙ low-mid
- ○ low

Categories	1. Link Between Science and Economics: Are benefit endpoints well established? Does science provide infomation needed for economic analysis?	2. Economic Methods: Are economic methods adequately developed?	3. Data Availability: Is data available from science and from economics for an assessment of benefits?	4. Expected Benefit: Are expected benefits large?	5. Value of Additional Information: With the goal of improving benefit estimates, what is the relative short-term return on investment?
Health: Mortality	high-mid	high-mid	high-mid	high	high
Health: Morbidity	high-mid	high-mid	high-mid	high-mid	high-mid
Visibility	high-mid	mid	low-mid	high-mid	high-mid
Materials / Cultural	low-mid	mid	low	high-mid	high-mid
Nonuse Value: Ecosystem	low-mid	low-mid	low-mid	high	mid
Aquatics: Recreation	high-mid	high	low-mid	low-mid	mid
Forests: Recreation	low-mid	high-mid	low	low-mid	mid
Ag. / Comm. Forestry	high-mid	high	mid	mid	low-mid
Radiative Forcing	low-mid	low	low	low-mid	low

Effect of Trading on Emissions

Percent Change in Title IV Baseline
Utility Emissions Attributable to Trading for 2005

Percent Change in Emissions

- <-25
- -25 to -10
- -10 to -0.01
- 0
- 0.01 to 10
- 10 to 25
- >25

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Effect of Trading on Health

Percent Change in Title IV Baseline
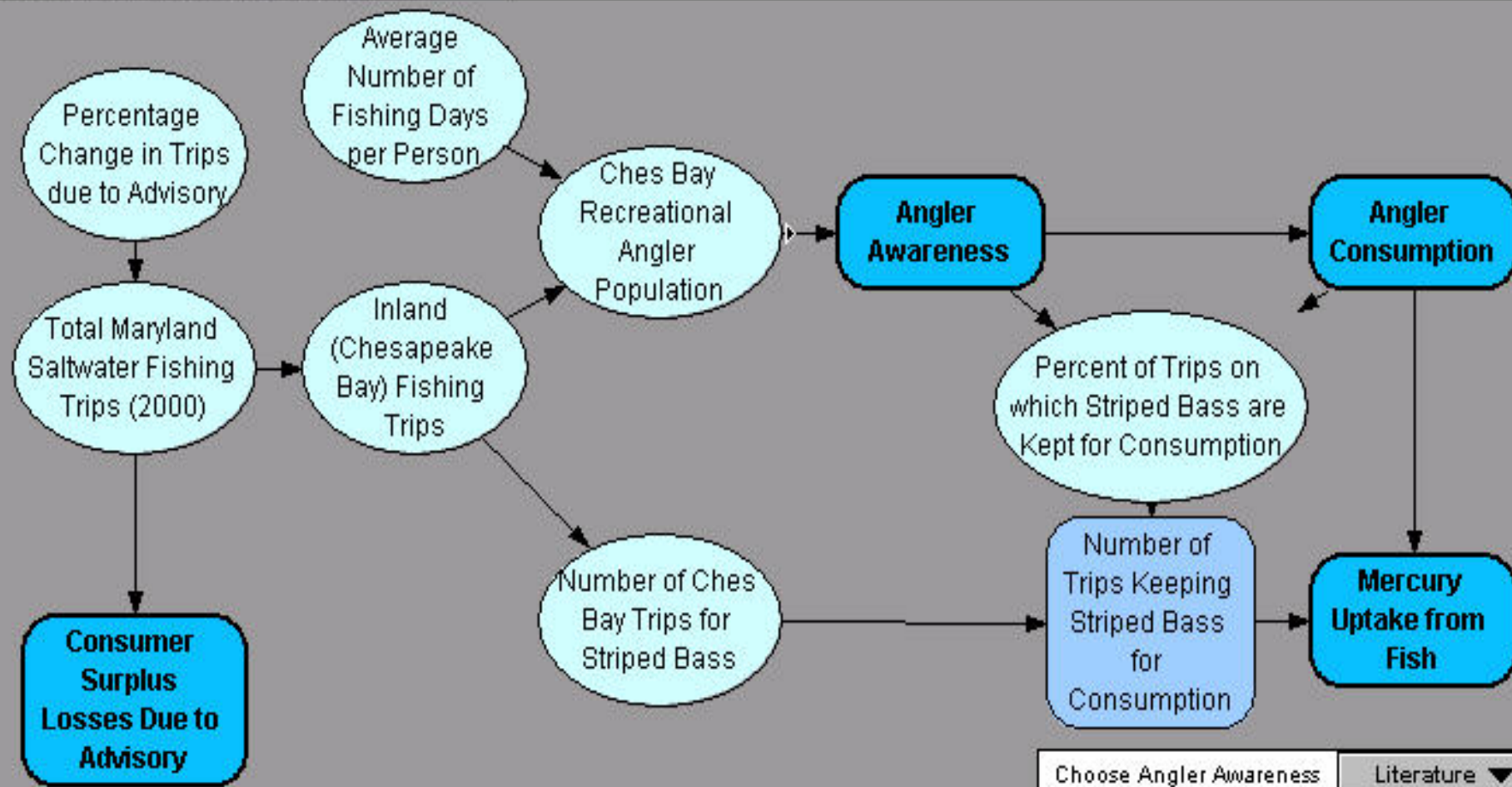Benefits Attributable to Trading for 2005

Percent Change in Benefits
- <-15
- -15 to -10
- -10 to -0.01
- 0
- 0.01 to 10
- 10 to 15
- >15

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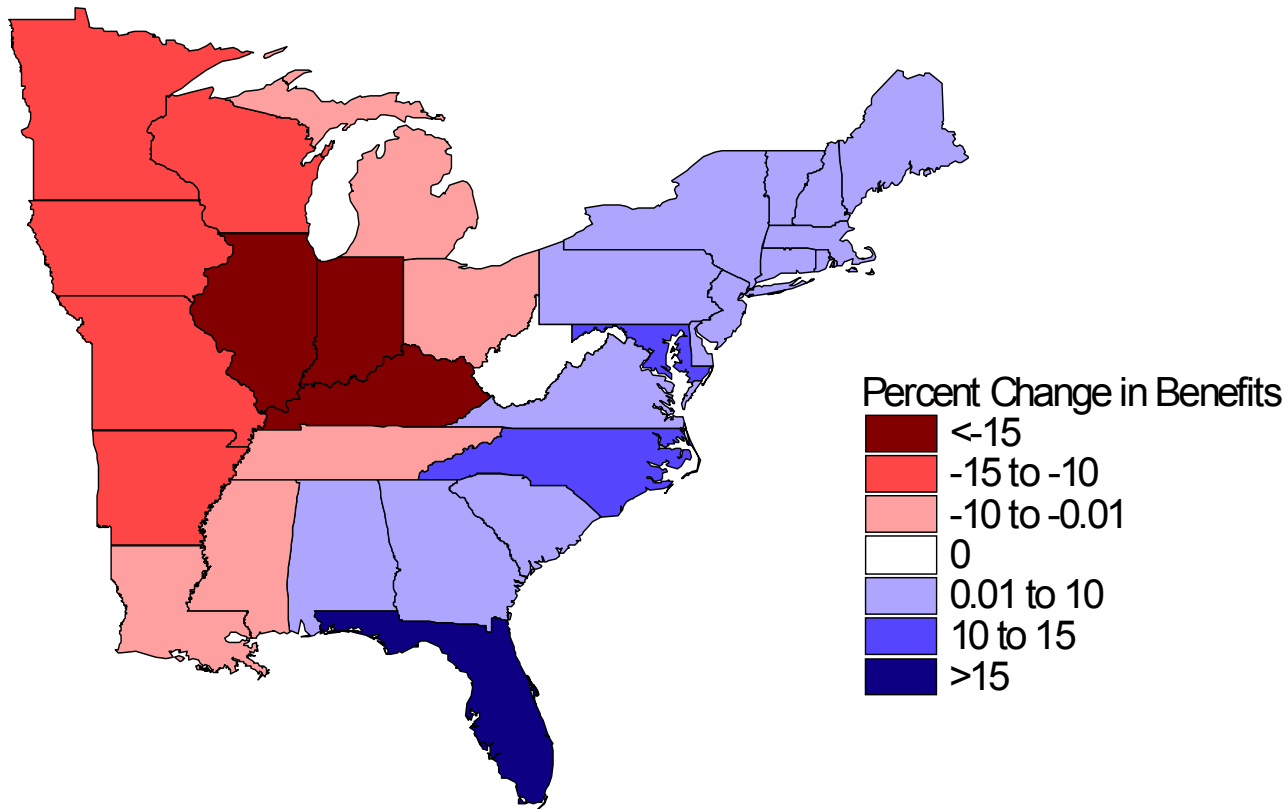
Effect of Trading on Deposition

Percent Change in Title IV Baseline Sulfur
Deposition Attributable to Trading for 2005

Percent Change in Deposition

- <-8
- -8 to -4
- -4 to -2
- -2 to -0.01
- 0
- 0.01 to 2
- 2 to 4
- 4 to 8
- >8
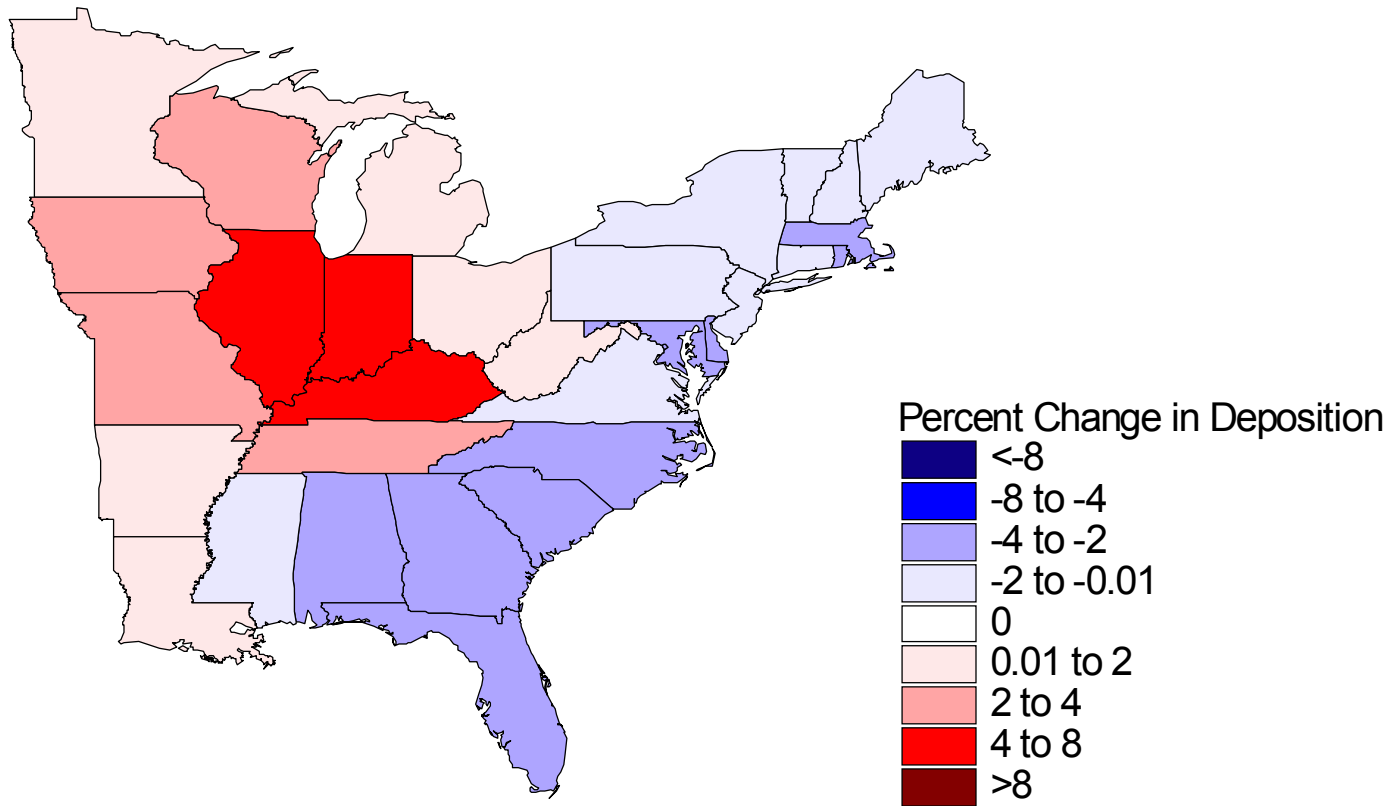
Benefits and Costs of Fish Consumption Advisories for Mercury

Paul Jakus, Meghan McGuinness, and Alan Krupnick

- TAF Submodules
  - Recreational angler behavior
 - Commercial market behavior
  - Mercury health effects

Recreational Angler Response ▼

Percentage Change in Trips due to Advisory

Average Number of Fishing Days per Person

Ches Bay Recreational Angler Population

Angler Awareness

Angler Consumption

Total Maryland Saltwater Fishing Trips (2000)

Inland (Chesapeake Bay) Fishing Trips

Percent of Trips on which Striped Bass are Kept for Consumption

Number of Ches Bay Trips for Striped Bass

Number of Trips Keeping Striped Bass for Consumption

Mercury Uptake from Fish

Consumer Surplus Losses Due to Advisory

Choose Angler Awareness | Literature ▼

Policy

Awareness

Choose Angler Awareness

Angler Types

Mercury Intake Distribution
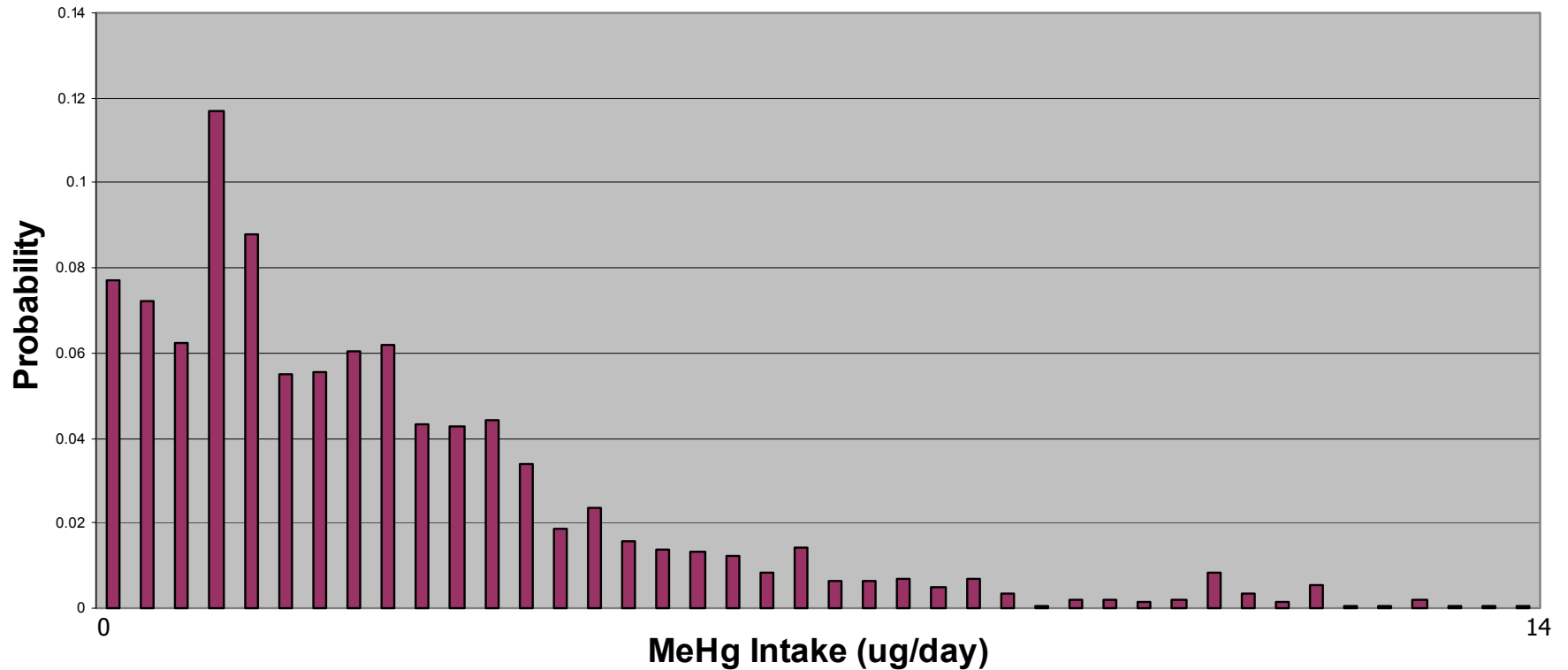
Change in Consumption Probabilities

Study	P(C|A)	P(C|NA)	% Reduction
Belton, et al. (1986)	0.353	0.702	49.7%
May and Burger, (1996) Arthur Kill	0.660	0.760	13.2%
May and Burger, (1996) NJ Shore	0.700	0.871	19.6%
MacDonald and Boyle, (1997)	0.375	0.478	21.5%
TAF Value			**26.1%**

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Estimating the Health Benefits of Recreational FCAs

- From Recreational Model: change in trip numbers and angler consumption patterns under an advisory imply a change in mercury exposure

- Using epidemiological and economic literature, estimate changes in health endpoints and value where possible

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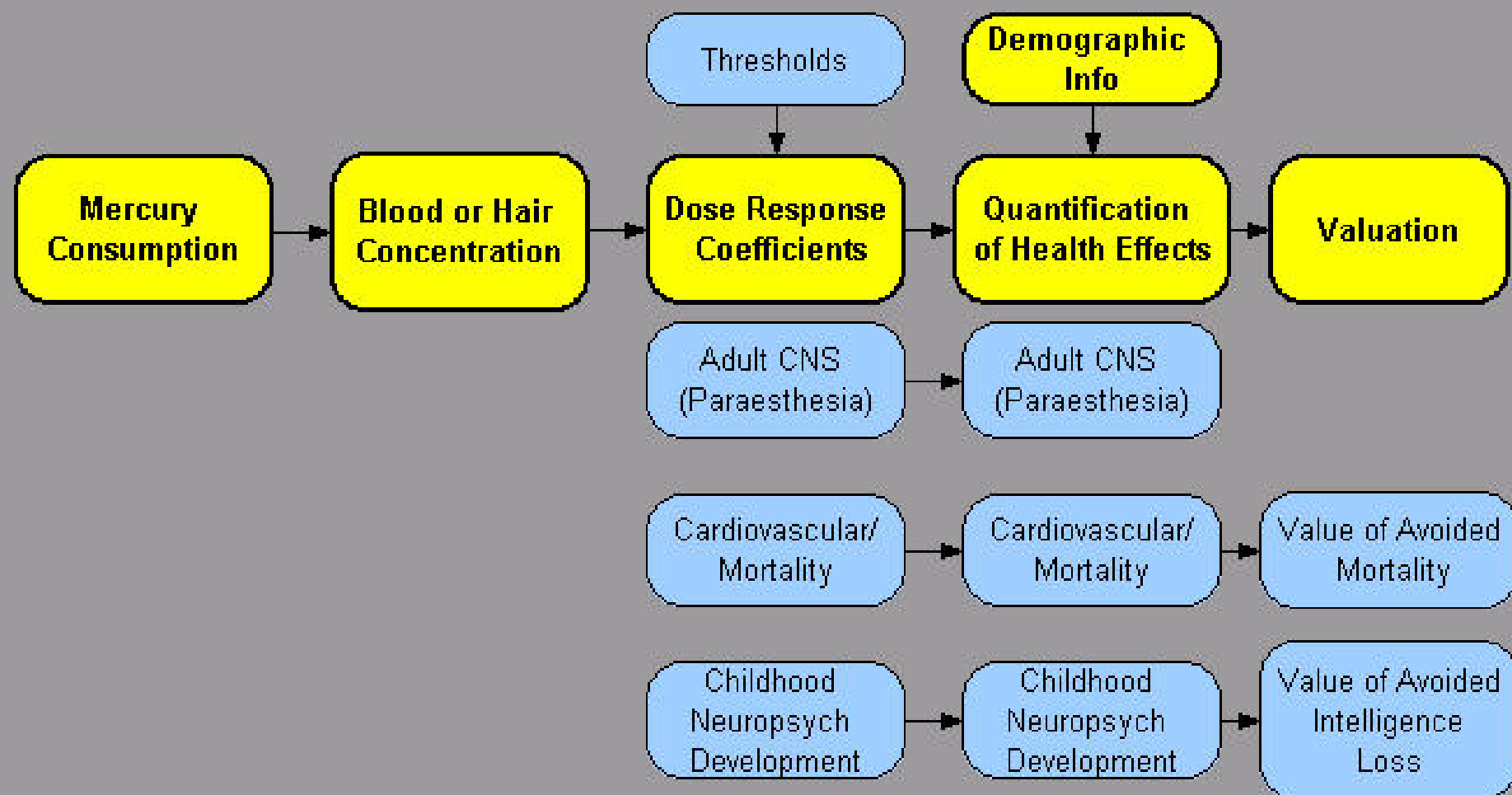
Overall Results

- Health benefits of an FCA: $0-$13-$71million
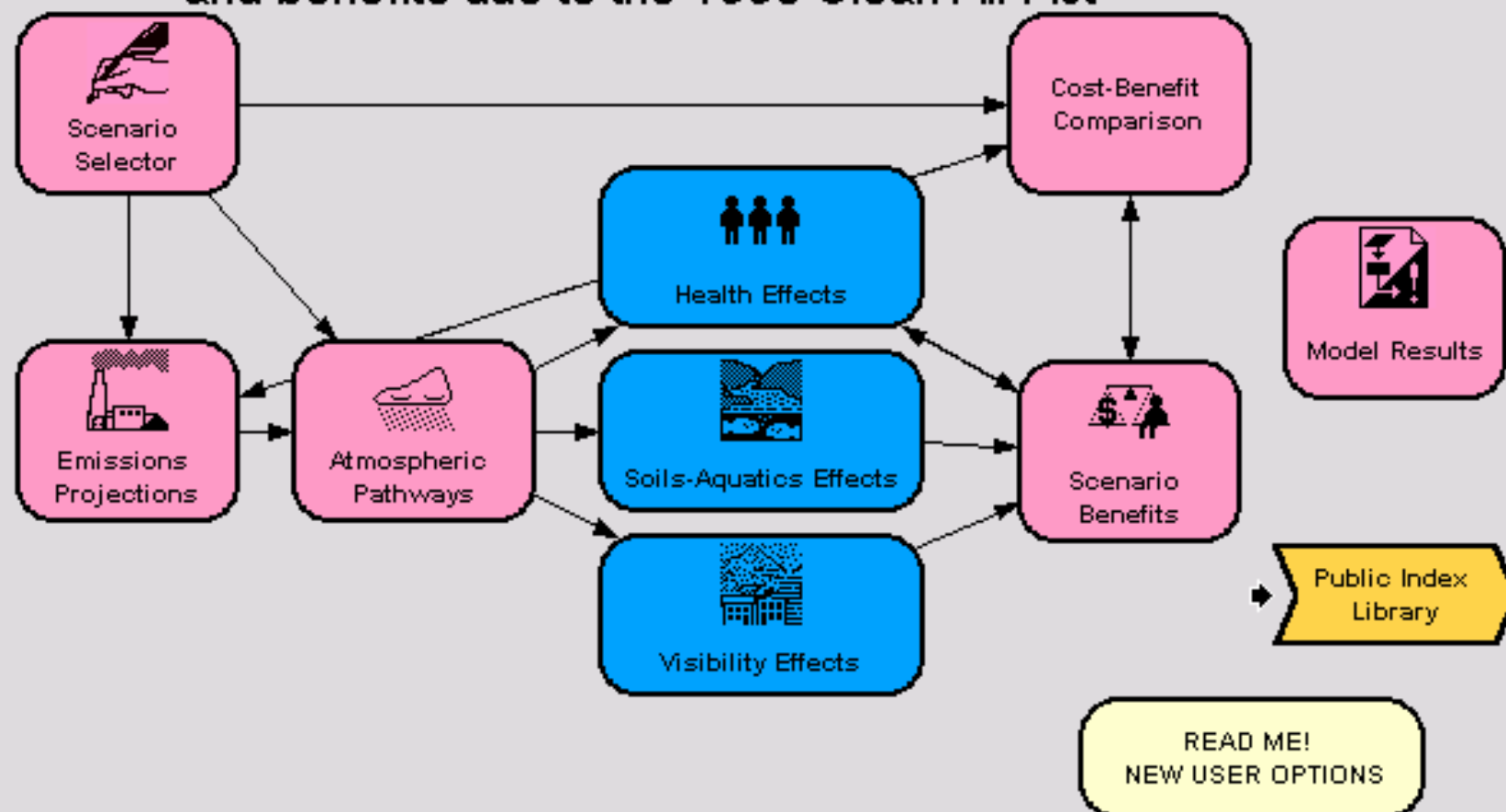- Utility loss to recreationists from FCA: $9 million
- Commercial fisheries loss: $0.5 million

Extensions

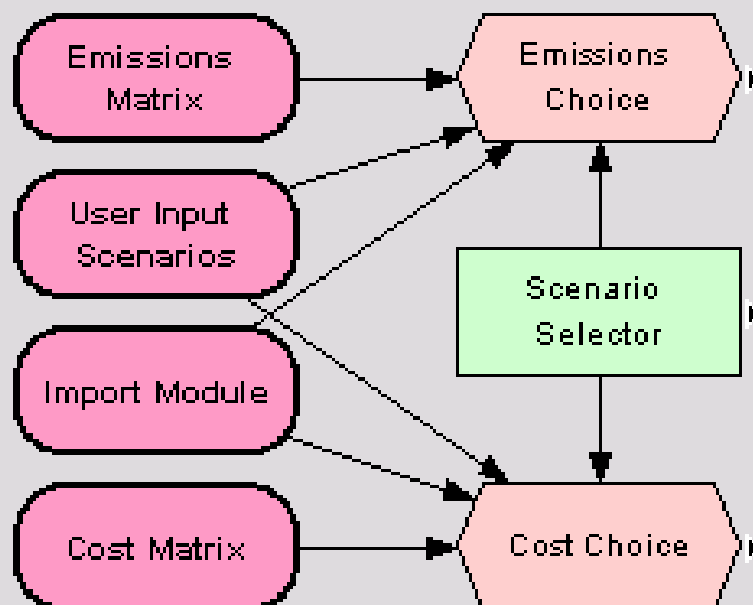- Scale to nation
- Automated benefit transfer
- Link to sources of emissions

See Description Field for Scenario Selection Instructions

Scenario Selector ⬛ New (Seasonal) ▼

Uncertainty Options

Emissions Matrix

User Input Scenarios

Import Module

Cost Matrix

Emissions Choice

Scenario Selector

Cost Choice

To use your own state level emissions da select "New" if emissions are reported annually, and "New (Seasonal)" if emissions are reported at the season leve Then, click on "Emissions Matrix." Paste emissions in the green box that correspor to your selected scenario.

This model has Baseline inputs for 2005, 2010, 2015, 2020 for SO2 and NOx from Tax_Z_10_F.ANA. This baseline includes the NOx SIP Call.
Comparison case for these years should be imported.

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Mortality Effects ▼

THE USER MUST CHOOSE AN OPTION FOR
ESTIMATING MORTALITY
Once an option is selected, the highlighted boxes indicate
where a mortality study must be chosen.

OTHER OPTIONS...

OPTION 3: DEFAULT SETTING. Treats nitrates as PM10, but applies a separate C-R
relationship for sulfates. The users chooses TWO mortality studies here. One PM mortality
study for computing age aggregated deaths, and one SO4 mortality study.

OPTION 4: Treats both nitrates and sulfates as equivalent in potency to sulfates. The user
chooses ONE study for computing SO4 mortality.

OPTION 5: NOT DEVELOPED. Option 5 will treat nitrates as equivalent to PM10 net of
sulfates.

OPTION 6: Used to calculated mortality from SO2. This calculates 0 mortality from suflates or
nitrates. This option acknowledges the debate in the literature over the relative roles of SO2
and particulates in raising mortality risks. This option should be viewed as an alternative to
analyzing PM10 mortality, rather than considering the effects as additive.

OPTIONS TREATING BOTH NITRATES AND SULFATES AS
PM10

OPTION 1: Nitrates and sulfates are treated as equivalent in
potency to PM10. The user chooses ONE PM mortality study for
computing age-aggregated deaths.

OPTION 2: Nitrates and sulfates are treated as equivalent in
potency to PM10, and the C-R relationship varies by age (over
65, under 65), such that reported deaths are disaggregated by
age group. The user chooses ONE PM mortality study for
computing age-disaggregated deaths.

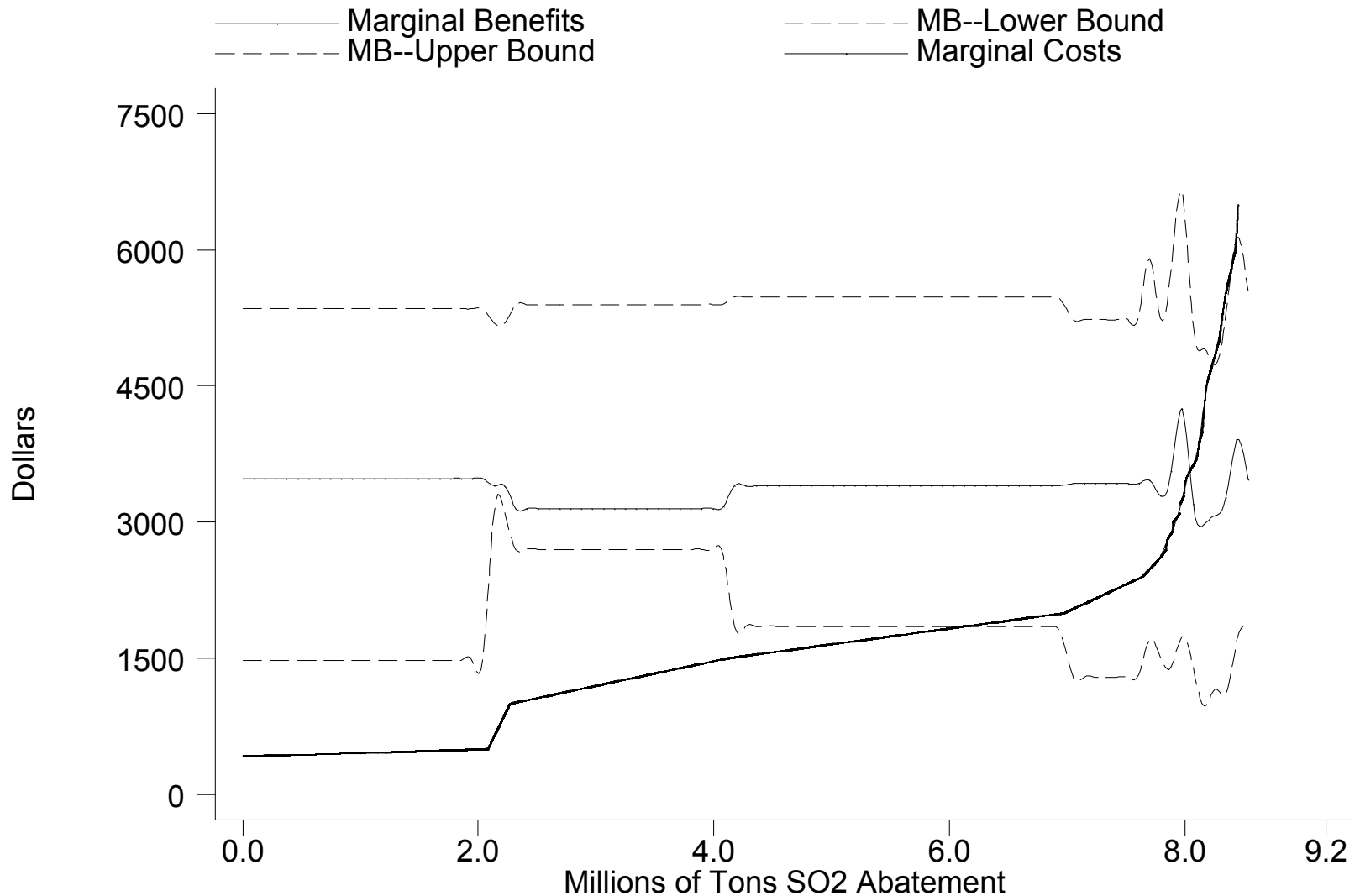|	
Option 1	Choose a study for computing age-aggregated deaths: **Pope et al. (1995)** ▼
Option 2	Choose a study for computing age-disaggregated deaths: **HB** ▼
Option 3*	Choose an SO4 mortality study: **Pope (1995)** ▼
Option 4	Choose an SO2 Mortality Study: **Hatzakis et al. (1986)** ▼
Option 5	
Option 6	Total Particulate Mortality Impacts (Deaths) (Calc) mid

Function
Definitions and
Library

Note: All PM mortality studies are reported in the library in terms of PM
10. Any study using another measure (e.g. TSP, PM 2.5) has been
converted. The notes for each study report the original measurement unit.

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RFF "Haiku" Electricity Model

- Intra-regional market modeling
  - Market equilibrium in 13 regions
  - Demand: 3 customer classes, 4 time periods, 3 seasons
  - Supply constructed using model plants
    - Defined by technology, fuel type, vintage
    - Investment and retirement
    - Emission compliance (SO_2, NO_X)
    - Fuel market prices adjust

- Inter-regional power trading
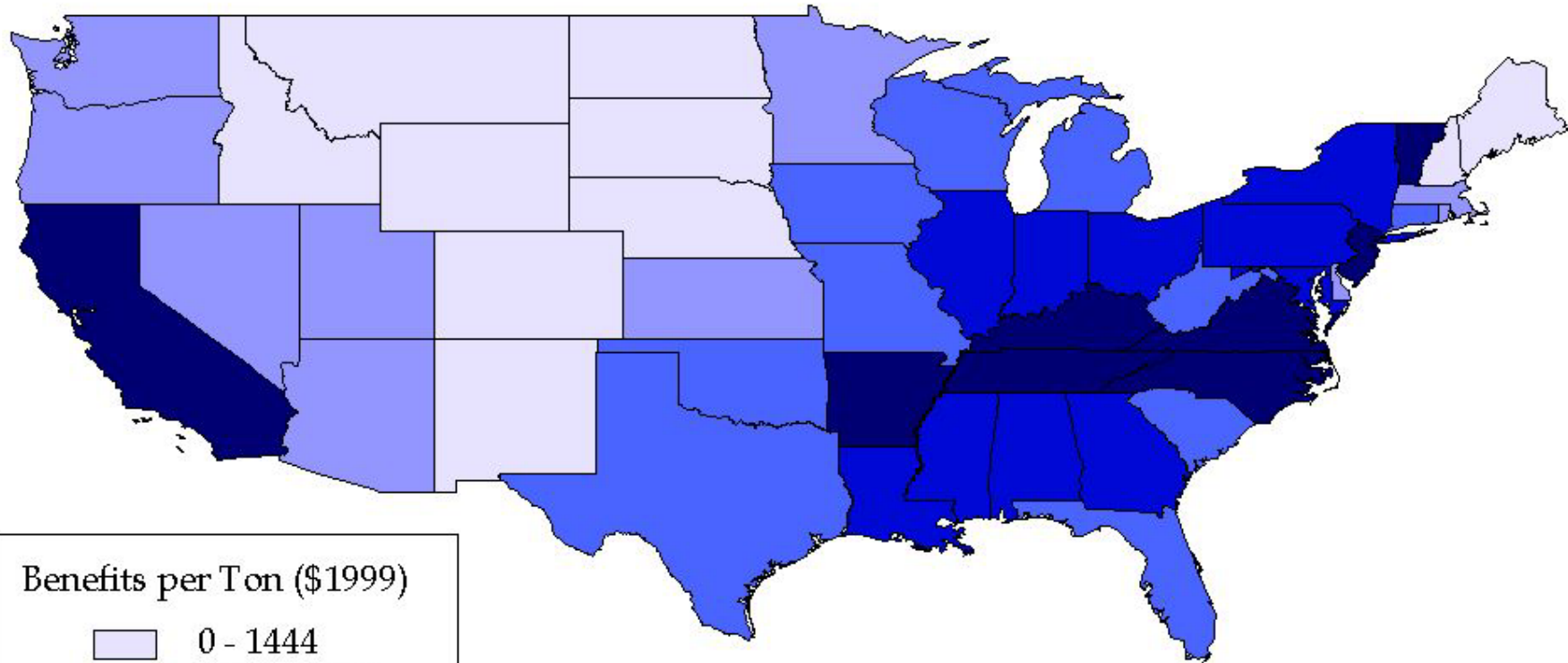 - Equilibrates regional prices, transmission constraints
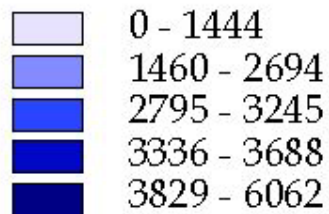
Marginal Benefits and Costs: SO$_2$

Marginal Benefits and Costs: NO$_X$

November 25th, 2002
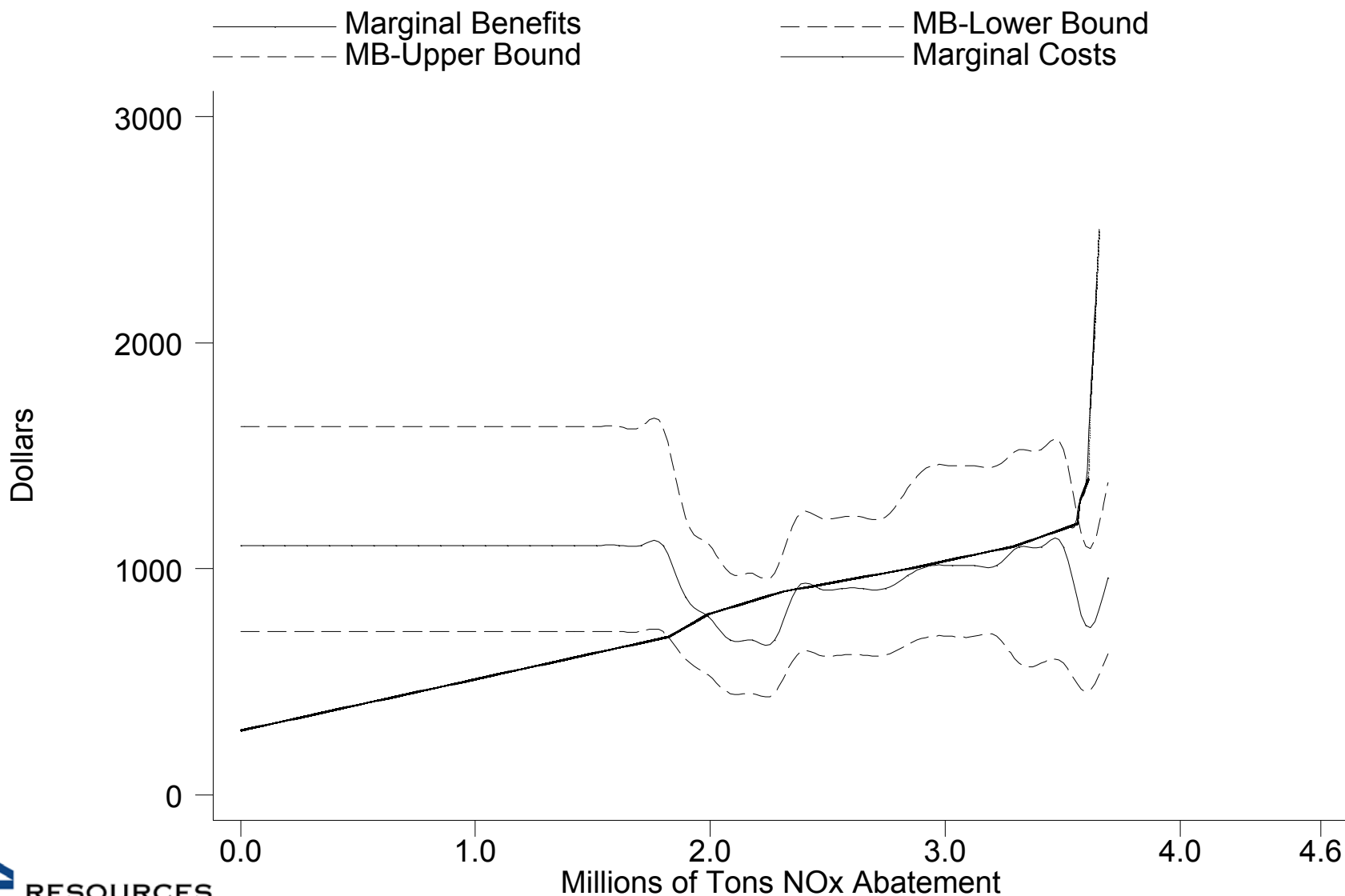
Value of Emission Reductions by State

Benefits per Ton ($1999)

- 0 - 1444
- 1460 - 2694
- 2795 - 3245
- 3336 - 3688
- 3829 - 6062

November 25th, 2002

Sample Applications

- "Integrated Assessment" (*NAPAP, 97*)
- "Benefits and Costs of Title IV" (*CEP*, 98)
- "Environmental Effects of Electric Industry Restructuring" (*REE*, 98)
- "Effects of Restructuring on Maryland" (PPRP, 98)
- "Integrated Assessment of Environmental Damages from Electricity Generation in Maryland"(PPRP, 00)
- "Regional Analysis of SO2 Allowance Trading" (*EST,* 99)

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Sample Applications (2)

- "Ancillary Benefits of Carbon Policies" (*JEEM,* 03; OECD 00)

- "Mercury & Fish Consumption Advisories (*in submission)*

- Acidification & Low Elevation New England Lakes (Rubin et al. 02)

- "Annual vs. Seasonal NOx Controls" (*JAWMA* 01; *Land* 03)

- "Efficient Emission Fees" (*PUF* 03; *in submission*)

- "Interpollutant Trading" (*Fordham Law,* 03)

Final Thoughts on Integrated Assessment, in Any Domain

- **Embrace and understand uncertainty** to assess confidence in your knowledge and in the policy implications of your assessment

- **Progressively refine model scope**, and **model components**, to improve credibility and relevance of your analysis to policy

- **Maintain an open architecture** to support easy model expansion, as well as adoption of the model by others

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